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Effects of cooking process on the level of heavy metal accumulation in vegetables: Literature review

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Abstract— *People, nowadays, consume vegetables, fruits and herbs contaminating such heavy metals either from polluted air or water sources without awareness on a daily basis. However, some vegetables are regularly consumed after going through the cooking process, while some are eaten freshly. This paper, therefore, gathers information regarding whether cooking methods are able to lower the level of heavy metal in food or not, focusing on vegetables. Finally, It could be concluded that different cooking methods have widely different effects on heavy metal concentration. In other words, some processes potentially minimize certain types of metal, while others may be unable. According to the studies, water is claimed to enhance the reduction of toxic substances concentration through the evaporation, therefore, boiling usually lowers some metal levels, though the change in such levels are not considerable and frequently not that adequate to be healthy. Moreover, there are other ways to eliminate such heavy metals directly in plants, namely flushing, and using DTPA, chemical substances which both are claimed to be potential methods.*

Keywords— ***Cooking methods, heavy metal, vegetables.***

I. INTRODUCTION

There are widespread measurements of heavy metals accumulation in plants. The study areas consider where there is a high probability that plants might absorb large amounts of heavy metals. Hydrophytes, plants living in water, absorb heavy metals from water they live in. Researchers, therefore, usually conduct samples from the river or water resources nearby factories or where people were packed in, which means water is highly utilized and tremendous amounts of wastes are released into the water sources. It is therefore lead to marked accumulation of heavy metals including lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg), Manganese (Mn), Zinc (Zn), Copper (Cu) and Nickel (Ni) [8] as well as other perilous chemical substances. Similarly, Embryophytes, land plants researchers often conduct samples where there is an avalanche of mining and manufacturing as it causes an enormous accumulation of heavy metals in the vicinity of soil, Embryophytes then absorb excessively such heavy metals from those contaminated soil. In addition to this, using chemical fertilizers or pesticides in plantations also causes the overwhelming heavy metals' accumulation which could lead to fatality in plants.

In recent times, there has been a dramatic increase in the number of globally contaminated vegetables, both home-grown vegetables and herbs [11]. This is due to the fact that the size of manufacture, where the polluted water; possibly contaminated with heavy metal, is normally released into the water sources such as lake and river, has grown substantially year by year and the water is then used for crop. Moreover, the number of passenger cars, buses and other motor vehicles which produce enormous amounts of pollution have also continued to increase exponentially and consequently lead to the rising amounts of heavy metal in the environment. When it comes to current agriculture, due to more and more fertilizer and pesticide being used for accelerating outcomes, soil becomes intensely and continuously contaminated with heavy metal. Organic pesticide is invariably added by several banes such as Copper (Cu), Mercury (Hg) and Arsenic (As) which are residue, so this can also cause contamination in soil and vegetables. It is

undeniable that people regularly eat vegetables such as carrot, onion, lettuce and cabbage in everyday life, thus when vegetables absorb heavy metal from soil [12], people consume them unaware of taking heavy metal into their bodies. Likewise, herbs, popularly used as an alternative treatment and added in many spices, also contain huge amounts of heavy metal. Therefore, related organizations of each country have determined an appropriately standard quantity of heavy metal to limit and make sure that it would not harm people in their countries because some metals are beneficial if intaking proper amounts such as Copper (Cu) and Iron (Fe).

However, when it comes to vegetable consumption, there are several fresh vegetables which people regularly eat, lettuce, cucumber, tomato, red and green oak in salad, for instance, while some vegetables are eaten after they are passed such cooking processes as boiling, steaming, frying, and stir-frying. Whether these cooking processes can lower the contaminants in vegetables and also in meats has sparked heated debates. Several researches have been conducted and has got different results, so this paper will review the effect of different cooking methods on the contents of these metals in certain plants and meats, focusing on vegetables and information was gathered from published papers and the findings from various authors.

II. BACKGROUND

2.1 Heavy metals frequently found in plants and effects on human body

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times [6] greater than that of water, with atomic numbers ranging from 23-92, totaling 72 elements in periods 4-7, such as cadmium, chromium, mercury, lead, etc. Some are useful in industry. Some are beneficial to the body, but some are toxic to the body. [1][2]

2.1.1. Cadmium: Cd

2.1.1.1. Benefits

Cadmium is used in several categories of industry including metal plating process to prevent rust and add luster, used as a lubricant, used in the battery manufacturing process, used as a component of paint, used in the production of plastics, used in the welding process, used as a mixture in fungicides and chemicals used in agriculture, used as a nuclear fission rate regulator in atomic reactors, used in the manufacture of fluorescent lamps, use to mix with other metals as an alloy to increase toughness and corrosion resistance, used in combination with other metals in the jewelry and jewelry industries.

2.1.1.2. Harm to the body

In nature, cadmium is always found in combination with zinc. It has an element with chemical and physical properties similar to zinc, which is a constituent of the enzyme. When entering the body, it can replace the atoms of zinc in enzymes causing toxic effects on the body including digestive system and metabolism failure, inhibition of the formation of red blood cells which then cause anemia, sluggish body, chills and fever, high blood pressure, heart disease and irregular heartbeat, kidney malfunction which leads to kidney failure, 'Itai-Itai disease' which causes pain in the joints and bones, blurred vision, diarrhea, vomiting, liver failure and, even worse, the likelihood of death. Moreover, if the body has cadmium more than 15 ppm, it will cause high proteinuria.

2.1.2. Chromium: Cr

2.1.2.1. Benefits

Chromium is a heavy metal that is widely used in many industries widely including tanning industry as a compound of Cr(OH)SO4), used as an ingredient in the manufacture of stainless steel, used in combination with iron, nickel and other metals to produce corrosion and high heat resistant alloy steels, used as a metal plating agent, metal coating as well as plastic coating to make it shiny and prevent corrosion, such as in the humid industry, automobile parts, etc., used as an ingredient in the production of dyes or pigments such as Chrome oxide green (Cr2O3), Chrome yellow (PbCrO4), Chrome orange (PbCrO4.PbO), as well as a dyeing agent in the textile and dyeing industry, used as a mixture of spray paint, house paint, used as a mixture of fungicides and wood preservative, used to produce dust deterrents and prevent corrosion of diesel engines, used as rust inhibitors such as dichromate compounds, used in the colored glass industry, especially Chromium(III), used in the production of heat-resistant bricks, used as a catalyst for chemical reactions and chemical synthesis, used in medicine such as chromium isotope (Cr-51). Moreover, Chromium (III) is a chromium that can be found in the human body. It plays an important role in the function of the hormone insulin that regulates blood sugar levels.

2.1.2.2. Harm to the body

Chromium toxicity to the human body is often caused by the poisoning of Chromium (VI), which is currently being used a lot in industry as a component of various products that are used by humans causing contamination to the environment and the most likely to enter the human body. Symptoms of chromium poisoning caused by the body's exposure to low to moderate amounts and have accumulated for a long time will gradually begin to appear in various organs of the body including inflammation of

the skin irritation; chronic wounds; slow wound healing; the mucous membranes of various internal organs are irritated and destroyed; kidney, liver and lung malfunction and damage; osteoporosis; cancer in various organs; respiratory failure and risk of sudden death.

2.1.3. Lead: Pb

Lead, when entering the body, has properties similar to calcium, that is, it accumulates in the bones and in the hair.

2.1.3.1. Benefits

Lead is used in various aspects. It is used in the soldering industry, in the petroleum industry and is a mixture of oil and fuel, used to produce batteries, used as a lead compound for mixing paint, used to make ammunition, used as an elemental alloy with copper and iron to enhance turning or cutting properties, and used to control the loudness of the sound of machinery (Thu Chan Nuan, 2007). Lead is, also, a component of important chemicals (Kittiphan Bangyikhan, 2008), such as pesticides.

2.1.3.2. Harm to the body

Intake of lead can cause several severe malfunctions of the body including acute poisoning such as physical exhaustion, dizziness, vomiting and muscle spasms; headache and difficulty sleeping; chronic poisoning which anemia and slim body are accounted. Furthermore, lead has an ability to inhibit the activity of enzymes as well as the process of red blood cell formation causing anemia. It can, in addition, results in bone decay, and creates damages in the nerve cells causing the brain to swell and inhibiting the activity of chemicals in the brain leading to the risk of dementia and neurological symptoms. Moreover, it could lead to kidney damage which then results in renal failure as well as reproductive system malfunction; weak sperm, ovarian atrophy, irregular menstruation and risk of infertility.

2.1.4. Mercury: Hg

2.1.4.1. Benefits

Mercury is an important ingredient in making thermometers. It is, further than that, used in the electrical industry, paper industry, paint industry, and used to synthesize pesticide. In ancient times, mercury was used as a component of syphilis medicine. It also has been used as an important ingredient of red medicine to heal fresh wounds.

2.1.4.2. Harm to the body

Mercury in methyl and ethyl forms is more toxic than metallic mercury or metal compounds. The least toxic mercury is in the form of organic compounds. Mercury has toxic effects on the body in many ways. An example of mercury poisoning is Minamata disease that leaks from an industrial plant in Minamata, Japan, where many people died from drinking water and eating food contaminated with mercury. The toxic effects on the body are abdominal pain, severe diarrhea, gum and salivary glands are destroyed and has a scorched appearance, nervous system malfunction, cause amnesia, blurred vision and may cause blindness.

2.1.5. Manganese: Mn

Manganese is found in water sources, surface and groundwater. If high in content it will turn the water into a cloudy reddish-brown color. This often occurs with iron.

2.1.5.1. Benefits

Manganese is used in wastewater treatment processes or water quality improvement system, used to make alloys to increase the strength of metals, used to produce electric welding rods, used to produce flashlights and batteries, used to make weaving machines, coating containers, paint products, cosmetics, rubber industry, printing machines, metal plating, and pesticides. In agriculture, it is used as a fungicide. Furthermore, manganese is a component of enzymes and bones which human body needs about 3-4 milligrams per day.

2.1.5.2. Harm to the body

If the body receives manganese more than the body's needs will cause poisoning including inflammation of the skin and mucous membranes of the gastrointestinal tract, body weakness and a headache, the nervous system is destroyed, trembling of the forearm and legs, and risk of partial paralysis (Jamlong Pintawong, Anon, Nonthaso and Sathaporn Kavinate, 2011). Moreover, manganese intaking may result in schizophrenia (Schizophrenia), emotionally unstable, difficulty swallowing speechless or hoarse. Tremors similar to Parkinson's disease are also found to occurred in some people.

2.1.6. Zinc: Zn

2.1.6.1. Benefits

Zinc is found existed in human body as a component of various enzymes. It helps to promote development in memory and learning in children, as well as the functioning of the reproductive system. Similarly, it helps a body to achieve fertility according to the appropriate age and stimulates the work of sex hormones. Additionally, it is used in plant growth accelerators or in fertilizers, used in the pharmaceutical industry, used to coat metal to prevent rust, and used as an octane booster in fuel industry.

2.1.6.2. Harm to the body

Zinc is well absorbed in the small intestine. When receiving high amounts of zinc, the body stimulates the

mucous membrane (mucosal epithelium) to synthesize metallothionein. Metallothionein, a protein rich in cysteine, binds to zinc by adhering to the intestinal cell wall and then loosening. However, if the amount of zinc is too high, it will accumulate in the liver and kidney area resulting in the following consequences including: internal organs destroyed, liver and kidney failure, anemia, chromosome abnormalities, risk of cancer, and the deficient in copper of the body due to inhibition of absorption. If zinc is taken more than 2 grams will cause acute poisoning including: diarrhea, vomiting and fever. Obtaining a good soluble zinc salt by ingestion in large quantities will cause nausea, vomiting, dehydration, severe abdominal pain, diarrhea, and if more than 45 g is obtained, more severe toxicity will occurs including: unconsciousness, blood transfusion and low urine output (On-Ing Vejsit, 2008)

2.1.7. Iron: Fe [7]

2.1.7.1. Benefits

Iron is a component of red blood cells and is used in biochemical processes such as digestion processes in the digestive system.

2.1.7.2. Harm to the body

Receiving high amount of iron and accumulation in the body will cause effects on various systems including: a decrease in digestive efficiency, dilation of blood vessels, lower blood pressure, slow blood clotting, decreased liver function, liver deterioration, and causing the activity of enzymes to be inhibited. When receiving less iron or the body is deficient in iron will result red blood cell synthesis to be inhibited, deprivation of oxygen of blood, and causing anemia.

2.1.8. Copper: Cu

2.1.8.1. Benefits

Copper is a metal that is essential to the body. To clarify, it is a part of the formation of hemoglobin and the function of some enzymes which are peroxidase and cytochrome oxidase. Copper also helps in delivering oxygen into cells. In addition, it is a component of many drugs; such as those that induce vomiting, burn wounds, anthelmintic drugs and fungicides. Copper is used in the manufacture of containers, furniture and metal industry, used as an ingredient in metal fabrication, used to produce wires and electronic circuits, used to produce chemical dyes, used in plant growth accelerators or in fertilizers, used as a component of pesticides, used to add into foods such as canned beans and some compotes such as Madan.

2.1.8.2. Harm to the body

If given through inhalation, copper will cause nasal congestion and sores on the roof of the mouth. Likewise, if taken by eating high doses, it will cause nausea, vomiting, abdominal pain, stomach bleeding, thirst, green vomit, dark color foamy urine (may cause fatality in 4 hours), neurotic symptoms, seizures, delirium, paralysis, balance disorder, and jaundice. Copper can cause itching and blistered skin if absorbed through the skin. If it gets into the eyes, it will cause conjunctivitis, swollen eyelids with black eye lesions. Some such have accumulation in tissues, causing a green color at the base of the hair and gums (On Ing Vejsit, 2008). If a human body receives more than 100 milligrams of copper, may has the following symptoms: body weakness, vomiting, anorexia, slim body, red blood cells break down, destruction of the liver, inhibition of the liver function. If the body has copper accumulation in the amount of 25-30 mg / body weight (kg) will cause cirrhosis. In addition, if the copper content in water is more than 0.1 ppm, it can cause toxic effects to aquatic animals as well.

2.1.9. Nickel: Ni

2.1.9.1. Benefits

Nickel is sed as a metal component in electrical appliances and electronic circuits. It is, also, used in combination with other metals to increase strength and luster.

2.1.9.2. Harm to the body

Nickel is an element that the body does not need. However, when it accumulates more higher and higher in the body, it can cause symptoms including: nausea, headache, vomiting and chest pain, weak and slim body, severe pneumonia, abnormally fast pulse, high blood pressure, risk of ruptured blood vessels in the brain which can lead to paralysis, and risk of cancer.

2.2 Plant Categories; considering ability in absorbing heavy metal

According to Baker's and Walker's study [9], some plant species have a physiological ability to adapt themselves surviving in the contaminated soil. As they had observed in their experiments, those plant species are able to grow naturally although they live in an enormously heavy metal contaminated soil. Moreover, each species represented a different ability in accumulation and Baker and Walker categorized plant species into three groups by using the ability to absorb heavy metals and also the organ which dominantly accumulates as a classification criterion.

2.2.1. Metal excluder

Metal excluder; Including plant species which accumulate heavy metals in its roots and no metals were found in other organs. For example, Cyperus articulatus L. is a cadmium excluder.

2.2.2. Metal indicator

Metal indicator; Including plant species which uptake heavy metals by its roots and deliver to other organs, particularly in aboveground parts such as leaves and stems. Due to the concentration of heavy metals in these parts comparable to the level in soil they lived in and directly proportional, these plants have been used as a metal indicator to identify the areas where there was highly heavy metals accumulation. For example, Ludwigia stolonifera (Ghill. & Pers) Raven was classified as cadmium and lead indicator.

2.2.3. Hyperaccumulator

Hyperaccumulator; Including plant species which absorb heavy metals by its roots and deliver to other parts, likewise Metal indicators do, though Hyperaccumulators accumulate substantially more heavy metals in aboveground organs than in soil parts. In addition, many environmentalists value these species and use them to deplete such toxins in soil as they are able to absorb large amounts of heavy metal. Nowadays, there are more than 500 hyperaccumulators including various plant species and families. For example, Leersia hexandra SW. is a lead and nickel hyperaccumulator [10].

2.3 How to measure the level of accumulative heavy metals in plants [13]

Spectrophotometers are a process based on the principle of measuring the absorption and transmittance of monochromatic light to measure biological quantities including chemical substances. The main components are as follows:

2.3.1. Light Source

The light source in the spectrophotometer must be emitted continuously and consistently in the desired wavelength as well as having enough light intensity. There are different types according to the wavelength of light emitted which must be selected to suit the liquid used to measure the absorbance

2.3.2. Cells used to contain the sample solution.

Cell samples are sometimes called cuvettes. The most common form is a simple glass cell. It is available only in the visible range because ordinary glass is absorbed in the UV range.

2.3.3. Monochromator

This component is used to control light by emitting light from a light source which is a monochromatic light and a single wavelength usually using prisms or gratings."

2.3.4. Detector

It measures the intensity of the absorbed radiation by converting the radiation energy into electrical energy. A good signal detector must have high sensitivity. So that, even if the amount of light changes slightly, it can detect the difference signal.

The light source is used to allow light to pass through the sample. A good light source should provide a consistent light intensity and remain constant throughout the wavelength. Currently, the most popular light sources are deuterium arc (190-220 nm), tungsten (350-2500 nm), and xenon lamp (190-800 nm).

Currently, spectrophotometers are being developed. The high efficiency of small sample volumes led to a system called Cuvette-less spectrophotometer.

2.4 How to use a spectrophotometer

2.4.1. Turn on the spectrophotometer. Select a light source and determine the desired wavelength of light. It should be turned on at least 15 minutes before use.

2.4.2. Choose a cuvette to suit the sample. Put the sample in the cuvette. Wipe the sides of the cuvette dry and clean.

2.4.3. Place the cuvette in the slot, close the lid, and read the absorbance from the display. The absorbance of the sample and null values are removed so that the results can be read from the display.

2.4.4. After use, clean the machine. Clean the cuvette and turn it off.

III. LITERATURE REVIEW

3.1 Food processing methods and accumulation of heavy metals [16]

Various studies have indicated heavy metal contamination in foods. Because of the harmful consequences of some of these metals, such as lead, mercury, and cadmium, this has become a more troublesome issue. There are several cooking methods, and these procedures increase the levels of heavy metals in the cooking process. Smoking, grilling, boiling, and frying, among other techniques, are all used in studies. Various amounts of such metals also were observed. On the other hand, there are conflicting data on the impact of various cooking processes on the concentration of these metals in food. While some studies show a drop in concentrations, others have found other results.

For the processing of raw food resources before consuming, a variety of cooking methods are available. Boiling, frying, roasting, barbequing, and grilling are some of the most popular methods.

The amount of metals in cooked fish cooked by grilling and frying was found to be greater than in raw fish. They suggested that the size of the fried fish was one of the causes for this outcome. They claimed that the size of the fish was inversely proportional to the amount of oil consumed and the amount of water lost during the preparation of food. As a result, when small amounts are cooked, more water is lost, resulting in a higher metal concentration.

Because heavy metals in food are soluble in water, they will be reduced during the cooking process. There is the loss of water rising temperature for the drop in metal concentration in the fried sample. Many variables, including the original levels of heavy metals in the cooking procedures might influence the decrease or increase of these components in the flesh.

There are no consistent consequences when it comes to the effects of various cooking processes on the amounts of various heavy metals. Factors from the surroundings during the cooking process have been identified as probable factors of the growth. This shows that the cooking method or heating isn't the most essential part in such experiments. As a result, it is in need of additional controlled studies in this field, with a wider sample. More research is needed on cooking processes in various circumstances (such as time, temperatures, and cooking mediums) in order to decrease the harmful impacts on food.

3.2 Effect of cooking method (soaking, washing, and cooking) on the content of heavy metals in rice [24]

According to Raafat A.,2020, the impact of the method of cooking on the heavy metals content of Iraqi rice available in the local market was examined. The result shows that the process of soaking, washing and cooking rice affected the concentration of the arsenic element to significantly decrease. This is made more solid by the study (Naito et al. 2015) of rice grown in Japan which indicated that the process of soaking, washing and cooking affected the arsenic concentration in it to leveled down about 20 times from initial, from 0.2104 to 0.01032 mg/kg.

Similarly, there is a decline in lead and cadmium concentration in rice after soaking and cooking treatments; being soaked and washed with water before being cooked. Also, a clear decrease in the concentration of lead and cadmium in rice when soaked with salt and acid and then cooked have been found by several studies.

However, there was no big difference in cadmium concentration according to the method of cooking. It was found that cooking without filtering cooking water or with filtering reduced the element concentration significantly, from 0.3922 mg/kg before cooking to 0.0955 mg/kg with no filtering and 0.09102 mg/kg with filtering (Naseri et al., 2014). Additionally, for cooking water, Ziarati and Azizi, 2014 indicated that cooking rice without soaking did not significantly reduce the concentration of cadmium, as it reached 0.3178 mg/kg after cooking compared to its concentration before 0.3276 mg/kg.

3.3 Effects of food processing methods (oil extraction, boiling, and infusing) on migration of heavy metals in oilseeds, noodles and teas [25]

According to Joon-Goo Lee et al., 2019, it was found that heavy metals (lead, cadmium, arsenic, and aluminium) in oilseeds, noodles and teas were reduced by extracting oils, boiling noodles, and infusing teas.

Oil extraction methods including mechanical pressing, solvent and supercritical-fluid extraction were used in the study. The results suggest that heavy metals were transferred from seeds to oils less than 10% by pressing and solvent extractions while the transfer rates of heavy metals were up to 30% in supercritical-fluid extraction. This is due to the fact that supercritical-fluid extraction extracts more heavy metals rather than other extraction processes, and therefore, is more effective in extracting components of seeds rather than solvent and pressing extractions.

Heavy metals were significantly decreased during boiling noodles; including flour noodles and glass noodles, for 3 minutes. Similarly, heavy metals were significantly decreased in tea infusion after infusing tea; including black tea, green tea and Solomon's seal tea, for 2 minutes. In addition, heavy metals contents were increased as the infusion time increased from 2 to 10 and 30 minutes resulted from the fact that the migration of heavy metals into tea infusion is metal dependent. Especially, black tea showed the highest migration rates and green tea had the lowest migration rates. Black tea was made from green tea by oxidation, which is called the fermentation procedure. Heavy metals bio-concentrate to metal chelates in plants and metal chelates would be changed by oxidation in black tea. Therefore, heavy metals in black tea would be easily migrated to infusion.

3.4 Effect of processing methods on heavy metal concentrations in commonly consumed green leafy vegetables available in Sri Lankan Market [14]

According to the effect of processing methods on heavy metal concentrations in commonly consumed green leafy vegetables available in Sri Lankan Market research, certain green leafy vegetables, whose leaves and young stems are edible. These edible parts of each vegetable were passed through 2 cooking methods, including cooking (boiled with coconut milk) and stir-frying. Thereafter, the level of

5 different heavy metals, namely Ni, Cd, Cr, Pb, and Cu are measured and compared with the raw ones.

The results were relatively consistent, with the level of almost all heavy metals in stir-fried vegetables reducing the most, followed closely by cooked ones, though the decrease was fairly minimal.

Moreover, the research indicates that these heavy metals are elaborated through various means, evaporation of water, and solubilization of the element for instance. Also, the metals possibly bind to such macronutrients present in food items as carbohydrate, lipid, and protein.

3.5 Effects of Different Cooking Methods on Heavy Metals Level in Fresh and Smoked Game Meat [15]

However, cooking methods do not only potentially reduce the level of heavy metals in plants but also in meat. Several studies have been conducted and obtained different results. According to Effects of Different Cooking Methods on Heavy Metals Level in Fresh and Smoked Game Meat research, different bush meats are cooked with various processes including, grill, boil, and fry and subsequently examined the level of such heavy metals as Fe, Mn, Cu, Zn, Cd, and Pb. The results were surprisingly inconsistent, especially for Iron (Fe), where boiled and grilled meats were reported to have higher metal levels, when compared to fresh one. When it comes to grilled and smoked meats, the researcher deduced that the increase in Iron concentration can be attributed to an interaction between meat and the metal grid. However, the level of Iron has not been frequently measured, when it comes to vegetables. The study eventually concluded that the different cooking methods had affected different heavy metal levels and the number of toxic substances in a food could be minimized by using the appropriate process.

3.6 Other methods on eliminating heavy metal in plant

3.6.1. Complexing agents; DTPA

The synthetic amino polycarboxylic acids; ethylenediaminetetraacetic acid (EDTA), nitrilotriacetic acid (NTA), and diethylenetriaminepentaacetic acid (DTPA) constitute a class of metal-complexing agents used in a range of applications including water treatment, pulp, and paper manufacturing, agrochemicals, photographic chemicals, industrial and domestic detergents, food processing, electroplating, textiles, cosmetics, pharmaceuticals, and medical detoxification [16]. NTA was first synthesized in 1862 and EDTA in 1935 (Egli, 2001). Aminopolycarboxylic acids act as a ‘chelant’, contain several carboxylate groups linked to one or more nitrogen atoms, and are able to form complex metal ions by forming stable heteroatomic rings (known as the ‘chelate effect’). These metal complexes are stable and water-soluble (Fiorucci et al., 2002) and restrict the metal ion from normal chemical interactions [17].

DTPA (Diethylenetriaminepentaacetic acid; C14H23N3O10), one of the commonly used chelant, was suitable for increasing the cadmium removal capacity of plants (i.e. Water hyacinth). Besides, it offers a suitable phytoremediation technique, the use of plants to extract and remove elemental pollutants or lower their bioavailability in soil (Berti and Cunningham, 2000) [18], to help clean contaminated sites [19], or in other words, helps in removal of heavy metals in soil and water where absorption of flora mainly occurs.

3.6.2. Plant flushing

Another effective way to remove heavy metals in plants is “plant flushing” [20]. Watering plants with clear water; without any contaminants (recommended PH of water is around 5.5-6) or using “flushing agent” containing chelating agent [23], specific chemical compounds whose structures permit the attachment of their two or more donor atoms (or sites) to the same metal ion simultaneously, around 1-2 weeks before harvest or depends on growing means [22] , without added any compounds or nutrients. When plants receive an excess amount of fertilizer for long times, salt will be produced and the PH of soil and nutrients will be imbalanced, resulting in ineffective products such as unpleasant chemical taste and smell. Plant flushing, therefore, not only enhances removal of excessive nutrients and compounds, but heavy metals and contaminants will be also removed through the process [21].

IV. CONCLUSION

To summarize, methods of cooking could decrease the level of heavy metal in vegetables, though the decrease has not been significant. However, these heavy metals are found to be evaporated through boiling as well as stir-frying processes, so this can be attributed to the help of water or such soluble as oil. Or else, metals should definitely migrate and accumulate in cooking mediums, frying oil, soup, and cooking stocks, for instance.

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